533 Rec'd PCT/PTO 16 AUG 2001

FORM PTO-1390 (REV 12-97) U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

DATE: Aug 16, 2001

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER: 54769US008

U.S. APPLICATION NO. (If known, see 37 C.F.R. 1.5): 09/926887

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/US00/03953	16 February 2000	25 March 1999

TITLE OF INVENTION
METHOD OF PRODUCING SUBSTRATE FOR PLASMA DISPLAY PANEL AND MOLD USED IN THE METHOD

APPLICANT(S) FOR DO/EO/US
MINNESOTA MINING AND MANUFACTURING COMPANY

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a FIRST submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a SECOND or SUBSEQUENT submission of items concerning a filing under 35 U.S.C. 371.
3. ☐ This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39 (1).
4. ☒ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2)).
   - ☐ is transmitted herewith (required only if not transmitted by the International Bureau).
   - ☒ has been transmitted by the International Bureau.
   - ☐ is not required, as the application was filed in the United States Receiving Office (RO/US)
6. ☐ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. ☒ Amendment to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   - ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
   - ☒ have been transmitted by the International Bureau.
   - ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   - ☐ have not been made and will not be made.
8. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371 (c)(4)).
10. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern other document(s) or information included:

11. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☒ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☒ A FIRST preliminary amendment.
    ☐ A SECOND or SUBSEQUENT preliminary amendment.
14. ☐ A substitute specification.
15. ☐ A change of power of attorney and/or address letter.
16. ☐ Other items or information:

Certificate of Express Mailing

Under 37 CFR 1.10, I certify that this entry of a PCT application into US National Stage is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service addressed to the Commissioner for Patents, Washington, DC 20231, on the date indicated below.

Express Mail Mailing Label No.	Signature of Person Mailing Application
EL601169327US	Robert J. Pechman
Date of Deposit	**Printed Name of Person Mailing Application**
16 Aug. 2001	Robert J. Pechman

U.S. APPLICATION NO (if known, see 37 C.F.R. 1.5) 09/915687	INTERNATIONAL APPLICATION NO.:PCT/US00/03953	ATTORNEY'S DOCKET NUMBER 54769US008

17. ☒ The following fees are submitted:	Calculations	PTO Use Only
Basic National Fee (37 CFR 1.492(a)(1)-(5)):		
☒ Search Report has been prepared by the EPO or JPO $860		
☐ International preliminary examination fee paid to USPTO (37 CFR 1.482) .. $690		
☐ No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445 (a)(2)) $710		
☐ Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO $1,000		
☐ International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4) $100		
ENTER APPROPRIATE BASIC FEE AMOUNT =	$ 860	
Surcharge of $ 130 for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(e))	$	

Claims	Number Filed	Number Extra	Rate		
Total Claims	15 -20 =	= 0	x $ 18	$ 0	
Independent Claims	3 -3=	= 0	x $ 80	$ 0	
MULTIPLE DEPENDENT CLAIM(S) (IF APPLICABLE)			x $ 270	$ 0	
			TOTAL OF ABOVE CALCULATION =	$ 860	
Reduction by ½ for filing by small entity, if applicable. A Small Entity Statement must also be filed. (Note 37 CFR 1.9, 1.27, 1.28)				$	
			SUB TOTAL =	$	
Processing fee of $ 130 for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest priority date (37 CFR 1.492(f)).				$	
			TOTAL NATIONAL FEE =	$ 860	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be **accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). $40.00 per property**				$	
			TOTAL FEES ENCLOSED =	$ 860	
				Amount to be refunded	$
				charged	$ 860

a. ☐ A check in the amount of $ _____ to cover the above fees is enclosed.
b. ☒ Please charge my Deposit Account No. 13-3723 in the amount of $ 860 to cover the above fees. A duplicate copy of this sheet is enclosed.
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NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

Send All Correspondence To:

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Patent
Docket No: 54769US008

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:
Chikafumi Yokoyama
Serial No.:
which is a 371 U.S. National Stage of
PCT/US00/03953
Filed: Herewith
Group Art Unit:
Examiner:
For: METHOD OF PRODUCING SUBSTRATE FOR PLASMA DISPLAY PANEL AND MOLD USED IN THE METHOD

CERTIFICATE OF MAILING	
I hereby certify that this correspondence is being deposited with the United States Postal Service as First Class Mail in an envelope addressed to: Commissioner for Patents, Washington, DC 20231 on:	
16 Aug. 2001	Robert J. Pechman
Date	Signature Robert J. Pechman, Reg. No. 45,002

PRELIMINARY AMENDMENT

Commissioner for Patents
Washington, DC 20231

Dear Sir:

Please enter the following preliminary amendment in the cited application.

In the Claims:

Please cancel claims 2-10 and add new claims 11-24.

Following is a clean version of the entire set of pending claims.

1. A method of producing a substrate for a plasma display panel by providing a rib on a base, which comprises the steps of:

contacting a rib precursor containing a first photo-setting initiator having a first absorption edge and a first photo-setting component closely with said base;

filling a mold, obtained by photo-setting of a second photo-setting initiator having a second absorption edge whose wavelength is shorter than a wavelength corresponding to said first absorption edge of said first photo-setting initiator, with said rib precursor;

exposing said rib precursor to light having a wavelength longer than a wavelength corresponding to said second absorption edge, thereby setting said rib precursor; and

removing said mold.

11. (New) The method according to claim 1, wherein the base and mold are transparent and exposure of the rib precursor to light is conducted via the base and mold.

12. (New) The method according to claim 1, wherein the mold is flexible.

13. (New) The method according to claim 1, wherein the first photo-setting initiator has the first absorption edge corresponding to a wavelength of 400 to 500 nm and the second photo-setting initiator has the second absorption edge corresponding to a wavelength of 300 to 400 nm.

14. (New) The method according to claim 1, wherein the first photo-setting component and second photo-setting component are acrylic resin.

15. (New) The method according to claim 1, wherein the rib precursor contains a powder of ceramic and optionally contains a powder of glass.

16. (New) A method of producing a substrate for a plasma display panel by providing a rib on a base, which comprises the steps of

filling a mold, obtained by photo-setting of a second photo-setting initiator having a second absorption edge whose wavelength is shorter than a wavelength corresponding to said first absorption edge of said first photo-setting initiator, with a rib precursor containing a first photo-setting initiator having a first absorption edge and a first photo-setting component,

contacting said rib precursor closely with said base,

exposing said rib precursor to light having a wavelength longer than a wavelength corresponding to said second absorption edge, thereby setting said rib precursor, and

removing said mold.

17. (New) The method according to claim 16, wherein the base and mold are transparent and exposure of the rib precursor to light is conducted via the base and mold.

18. (New) The method according to claim 16, wherein the mold is flexible.

19. (New) The method according to claim 16, wherein the first photo-setting initiator has the first absorption edge corresponding to a wavelength of 400 to 500 nm and the second photo-setting initiator has the second absorption edge corresponding to a wavelength of 300 to 400 nm.

20. (New) The method according to claim 17, wherein the first photo-setting component and second photo-setting component are acrylic resin.

21. (New) The method according to claim 16, wherein the rib precursor contains a powder of ceramic and optionally contains a powder of glass.

22. (New) An assembly of a mold for making a substrate for a plasma display panel comprising a base and ribs, said mold having concave portions, and a rib precursor for forming said ribs said rib precursor being disposed in said concave portions of said mold and containing a first photo-setting initiator having a first absorption edge and a first photo-setting component, said mold being obtained by photo-setting a second photo-setting component in the presence of a second photo-setting initiator having an absorption edge whose wavelength is shorter than a wavelength corresponding to said first absorption edge of said first photo-setting initiator.

23. (New) The assembly according to claim 22, wherein said mold is flexible.

24. (New) The assembly according to claim 23, wherein said mold is transparent.

REMARKS

Claims 2-10 have been cancelled. New claims 11-24 have been added. The newly added claims substantially replicate the cancelled claims, and are being presented to remove the original multiple dependencies. Claims 1 and 11-24 are pending.

Support for the newly added claims may be found in the originally filed application. Specifically, all newly added claims are supported by the originally filed claims.

Examination and consideration of the application as amended is requested.

Respectfully submitted,

By [signature]
Robert J. Pechman

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METHOD OF PRODUCING SUBSTRATE FOR PLASMA DISPLAY PANEL AND MOLD USED IN THE METHOD

The present invention relates to a method of producing a substrate for a plasma display panel (hereinafter also referred to as "PDP") and a mold used in the method.

Background

PDP is expected to be used as a thin large-image display device. Generally, PDP is equipped with a so-called substrate for PDP. Typical substrate for PDP is composed of a pair of glass flat plates facing each other at a distance via a rib having a predetermined dimension (also referred to as a barrier rib, partition or barrier). In this case, such a rib separates space between a pair of glass plates into cells in an air-tight manner to form a plurality of discharge display cells capable of containing a discharge gas such as neon, helium or xenone.

Various suggestions have been made to produce and provide the rib and, for example, a method of using a mold is known. Generally, according to this method, a molding material is filled up in the mold and is converted into a molded article capable of transferring to a plate-shaped base by a thermal or optical action. On removing the mold from the rib, the rib is produced and provided, nearly continuously, with comparatively high accuracy.

In the case of a general substrate for PDP, for example, a base made of glass or ceramic and a rib are used. On the other hand, a mold for a typical substrate for PDP is made of a metal, glass or ceramic as disclosed, for example, in Unexamined Patent Publication (KOKAI) No. 9-12336. Accordingly, the base and rib have almost the same hardness as or lower than that of the mold. As a result, when the mold is removed from the rib, there is a fear of causing breakage of the base or rib, or breakage of the mold itself. Such severe breakage often occurs when the rib is press-molded by using a mold made of glass, ceramic or metal as disclosed in Unexamined Patent Publication (KOKAI) No. 9-283017. The mold is repeatedly used for mass production. It is not preferred to leave the broken rib in the mold, since it is necessary to wash the mold every time the rib is made, thereby lowering the productivity.

Unexamined Patent Publication (KOKAI) No. 9-134676 also discloses that a mold made of a silicone resin having a hardness lower than that of glass or ceramic is used. However, the silicone resin is generally brittle. Accordingly, it cannot be expected to repeatedly use the mold made of the silicone resin for mass production.

Summary of the Invention

It is an object of the present invention to provide a method of producing a substrate for PDP, capable of repeatedly using a mold with avoiding breakage of a base or a rib, and a mold used in the same.

According to the present invention, there is provided a method of producing a substrate for a plasma display panel by providing a rib on a base, which comprises the steps of:

contacting a rib precursor containing a first photo-setting initiator having a first absorption edge and a first photo-setting component closely with said base;

filling a mold, obtained by photo-setting of a second photo-setting initiator having a second absorption edge whose wavelength is shorter than a wavelength corresponding to said first absorption edge of said first photo-setting initiator, with said rib precursor;

exposing said rib precursor to light having a wavelength longer than a wavelength corresponding to said second absorption edge, thereby setting said rib precursor; and

removing said mold.

The term "absorption edge", used in the present specification refers to a wavelength portion wherein an absorbency in a continuous light absorption spectrum of an object drastically decreases and it becomes transparent when the wavelength becomes longer than said wavelength portion.

According to the present invention, there is also provided a mold for a substrate for a plasma display panel comprising a base and a rib formed from a rib precursor containing a first photo-setting initiator having a first absorption edge and a first photo-setting component, said mold being obtained by photo-setting a second photo-setting component in the presence of a second photo-setting initiator having an absorption edge whose wavelength is shorter than a wavelength corresponding to said first absorption edge of said first photo-setting initiator.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a partially exploded perspective view showing one embodiment of the substrate for PDP.

Fig. 2 is a flow sheet showing the steps of the method of producing the substrate for PDP according to the present invention.

Detailed Description

The present invention will be described by way of the following embodiments but is not limited thereto, as is apparent to a person with ordinary skill. In the drawings, the same reference numeral is applied to the same or equivalent portion.

In a partially exploded perspective view of Fig. 1, one embodiment of the substrate for PDP according to the present invention is schematically shown. This substrate 10 for PDP is used so-called A.C. PDP and is preferably equipped with transparent flat plates made of easily available soda-lime glass, which are facing each other at a distance, i.e. a back plate 12 and a front plate 14. Between the back plate 12 and front plate 14, plural ribs 16 having a predetermined dimension are provided to separate the space between the plates into cells, thereby making it possible to form a plurality of discharge display cells 18.

The rib 16 shown in the figure is formed from a photosensitive paste (rib precursor). Preferable photosensitive paste contains a first photo-setting component as a binder component, a photo-setting initiator having a first absorption edge and a ceramic powder and, if necessary, a glass powder. The ceramic powder is used for affording a fixed shape to the rib, and is preferably made of alumina, silica, titania or wollastonite having high strength.

The first photo-setting component is photopolymerized in the presence of the photo-setting initiator having a first absorption edge, thereby making it possible to retain the shape of the rib 16. The first photo-setting component is not specifically limited, but is preferably an acrylic resin. For example, the first photo-setting component may also be made from an acrylic monomer or oligomer, or a silane coupling agent having a methacryl group. Specifically, HEMA (hydroxyethyl methacrylate), HEA (hydroxyethyl acrylate), Bis GMA (bis-phenol A diglycidylether methacrylate) or triethylene glycol dimethacrylate monomer or oligomer thereof etc. can be preferably used.

Particularly, when the first photo-setting component is made of a silane coupling agent having a methacryl group, a network is formed by photopolymerization of the methacryl group, thereby making it possible to retain and contain the ceramic powder. In addition, the first photo-setting component of the silane coupling agent forms polymeric silicon dioxide having a high melting point by calcination. This network due to the silane coupling agent is substantially retained by silicon dioxide event at comparatively high temperature after calcination, thereby making it possible to retain the ceramic powder or glass powder. Such a silane coupling agent is preferably γ-methacryloxypropylmethyltrimethoxysilane, γ-methacryloxypropylmethyldimethoxysilane, γ-methacryloxypropyltriethoxysilane or γ-methacryloxypropylmethyldiethoxysilane having a molecular weight of 232 to 290 in view of availability.

The glass powder is used to enhance the strength by affording a dense structure to the rib. Basically, the glass powder is used in the amount enough to fill up small space between the network made of silicon dioxide and the ceramic powder surrounded with the network. When the network does not exist, it is not necessary that the glass powder does not fill up large space between ceramic powders. As a result, the strength of the rib can be increased by a comparatively small amount of the glass powder. For example, even if the glass powder exclusively contains lead having high mass adsorption coefficient, the rate of photo-setting is hardly influenced. Use of the glass powder made of expensive glass having a low melting point can also be inhibited. Basically, the glass powder is contained in the amount of 10 to 70% by volume. Preferably, the glass powder is contained in the amount of 20 to 50% by volume, thereby further increasing the strength of the rib.

When this network is heated, together with the glass powder, the network is retained as far as silicon dioxide constituting it does not reach the melting point of silicon dioxide, thereby to cause no change in volume, substantially. If any change in volume arises, the degree is small.

When the front plate 14 or back plate 12 is, for example, made of glass having an annealing point of 550°C, the glass powder preferably has a softening point of 450 - 550°C lower than the annealing point of the plates. Even if the glass powder having such a softening point is heated together with the front plate or back plate of glass to flow into a gap, a thermal deformation of the front plate 14 or back plate 12 can be prevented. The

glass powder is made of lead glass containing boron, zinc, phosphoric acid, lead, titanium or a combination thereof, aluminum phosphate glass, boron-titanium glass, bismuth glass or zinc glass. In order to reduce the time of photo-setting of the rib precursor without taking high mass absorption coefficient into consideration, boron, zinc, phosphoric acid, titanium or a combination thereof is preferably contained. In this case, each composition is not specifically limited.

In each discharge display cell 18, an address electrode 20 is provided on a back plate 12 along a rib 16. On a front plate 14, a transparent bus electrode 22 made of an indium tin oxide (ITO) is provided vertically to the rib 16. In addition, a discharge gas such as neon, helium, xenone or the like is contained between the address electrode 20 and bus electrode 22, thereby making it possible to emit light by discharge. On each address electrode 20, a fluorescent layer 24 is provided in a predetermined order, thereby making it possible to perform color display. On the front plate 14 and bus electrode 22, a transparent dielectric layer 26 is provided to coat the bus electrode 22, thereby making it possible to extend life of PDP by inhibition of sputtering of the bus electrode 22.

With reference to a flow sheet showing the steps of the production of the substrate for PDP shown in Fig. 2, formation of a rib and an apparatus therefor will be described in detail below.

First, a mold 30 having a concave portion 28 corresponding to the shape of a rib 16 is prepared (see Fig. 2(A)). Not shown in the drawing, the concave portion 28 may have a section in the shape of trapezoid. Also not shown in the drawing, releasability may also be imparted to the mold by coating the surface of the concave portion with a releasing agent.

This mold 30 can be obtained by photo-setting of a second photo-setting component in the presence of a second photo-setting initiator having a second absorption edge. As the second photo-setting component, an acrylic monomer or oligomer can be used. Specifically, as an acrylic monomer or oligomer, an aliphatic urethane acrylate, commercially available from Henschel Co. in the tradename of "Photomer 6010", or 1,6-hexanediol diacrylate commercially available from Shin-Nakamura Chemical Co. can be preferably used. Since the mold is molded by photopolymerization, cutting of the resulting mold 30 is not required. Since photopolymerization proceeds comparatively quickly, the mold 30 can be easily obtained in a short time.

Since such a mold 30 has a hardness lower than that of general glass or ceramic, breakage of the rib and base can be avoided in case of removing the mold from the substrate. As a result, the mold can be repeatedly used without being washed.

As mentioned above, photopolymerization of the second photo-setting component is conducted in the presence of the second photo-setting initiator having a second absorption edge whose wavelength is shorter than a wavelength corresponding to the second absorption edge of the first photo-setting initiator. Such a second photo-setting initiator cannot absorb light whose wavelength is longer than a wavelength corresponding to the second absorption edge. On the other hand, when the rib precursor is set by light having a wavelength longer than a wavelength corresponding to the second absorption edge, only the first photo-setting component is set by photopolymerization, thereby making it possible to avoid simultaneous photopolymerization of the second photo-setting component, even if unreacted second photo-setting component is remained in the mold 30. Preferable photo-setting initiator includes, for example, aminoketones (400 - 430 nm), bisacylphosphine oxide (440 nm), camphorquinone (500 nm), metallocene hydroxyketone (500 nm) and benzyl dimethyl ketal (380 nm), and are commercially available from Ciba Geigy Co. under the trade name of Irgacure 2959 (370 nm), Irgacure 184 (380 nm), Dalocure 1173 (380 nm), Irgacure 500 (380 nm), Irgacure 1000 (380 nm), Irgacure 651 (390 nm), Irgacure 907 (400 nm), Irgacure 149 (420 nm), Irgacure 1700 (440 nm), Irgacure 1850 (440 nm), Irgacure 819 (450 nm), Irgacure 369 (480 nm) and Irgacure 784 (500 nm). Accordingly, selection of the first photo-setting initiator and the second photo-setting initiator can be done by appropriately select two kinds of photo-setting initiators having different absorption edges listed above. A combination of the first photo-setting initiator and second photo-setting initiator includes, for example, Dalocure 1173 having an absorption edge at a wavelength corresponding to 380 nm and Irgacure 819 having an absorption edge at a wavelength corresponding to 440 - 450 nm, Irgacure 1700 and Irgacure 1850, or the like.

Then, a photosensitive paste 32 is applied on the mold 30 and the concave portion 28 is filled with it (see Fig. 2(B)). The photosensitive paste 32 preferably has a viscosity of 1×10^3 to 1×10^5 cps. By using the viscosity within such a range, filling up of the photosensitive paste can be conducted with high accuracy. The photosensitive paste

containing a silane coupling agent as the first photo-setting component may contain a mineral acid such as hydrochloric acid, nitric acid or the like to hydrolyze the silane coupling agent, thereby providing a photosensitive paste in the form of a sol. Such a photosensitive paste is not gelled by drying, thereby making it possible to disperse the ceramic powder and ceramic powder. Furthermore, the viscosity does not depend on the amount of water.

Then, a back plate 12 is made contact with the photosensitive paste 32 (see Fig. 2(C)). The second photo-setting component mentioned above can impart flexibility to the mold 30 on photopolymerization. In such case, the mold 30 is made contact with the photosensitive paste 32 from one end by bending the mold. Accordingly, an air between the back plate 12 and the photosensitive paste 32 is efficiently removed out to the exterior and infiltration of the air into the photosensitive paste 32 is also avoided.

Then, the first photo-setting component is polymerized by exposing the photosensitive paste 32 to light (hv) having a wavelength longer than that of the second absorption edge of the second photo-setting component, thereby obtaining a rib molded article 34 (see Fig. 2(C)). In this case, the polymerization is basically conducted only by light exposure and does not require heat management whose control is difficult, in principle. The second photo-setting component of the present embodiment can also impart transparency to the mold 30 on photopolymerization. When the mold 30 is transparent, exposure of the photosensitive paste 30 to light can be conducted simultaneously from both surfaces through not only the back plate 12 but also through the mold 30. As a result, light can sufficiently reach the first photo-setting initiator and first photo-setting component, which exist in the depths of the concave portion 28, and the unreacted first photo-setting component is not remained at the free end of the molded article 34. Furthermore, substantially uniform mechanical strength is afforded to the molded article 34.

Light used for exposure has a comparatively long wavelength and is absorbed only in the first photo-setting initiator. Therefore, light is not substantially absorbed by the second photo-setting initiator, and only the polymerization of the first photo-setting component is initiated to obtain the molded article 34. As a result, even if the unreacted second photo-setting component is remained in the mold 30, it is possible to inhibit the unreacted second photo-setting component from reacting with the first photo-setting

component. That is, the molded article 34 is capable of avoiding adhesion to the mold 30 by photopolymerization.

Then, the molded article 34 is removed from the mold 30, thereby transferring the molded article 34 integrally to the back plate (see Fig. 2(D)). As mentioned above, adhesion of the molded article 34 to the mold is avoided. Accordingly, such a removal can be easily conducted without causing breakage of the back plate 12 or molded article 34 or its free end, thereby to leave it in the mold 30. As a result, it becomes possible to repeatedly use the mold 30 without being washed, thereby making it possible to improve the productivity of the substrate for PDP.

Then, both of the molded article 34 and back plate 12 are put in a calcining oven (not shown) and calcined at a predetermined temperature to obtain a rib 16 (see Fig. 2(E)). Before and after this calcination, retention of the network mentioned above is substantially made, thereby reducing shrinkage of the molded article. Accordingly, it is possible to make a rib corresponding to the shape of the concave portion with good accuracy.

If necessary, an address electrode may also be formed between ribs on the back plate, and fluorescent layer may be provided on the address electrode. Then, a transparent front plate, on which a bus electrode has previously been formed, may also be disposed to face with the back plate via a rib. Furthermore, the peripheral portions of the front plate and back plate may be sealed in an air-tight manner by using a sealing material which is not shown in the drawing, thereby forming a discharge display cell between the front plate and back plate. Thereafter, the discharge display cell may be evacuated and a discharge gas may be introduced to form a substrate for PDP.

Although the present invention has been described in accordance with the a.c. substrate for PDP, it is understood by a person with ordinary skill that the present invention can also be applied to the d.c. substrate for PDP.

Examples

Example 1

A photosensitive paste was prepared in the following procedure. First, 4g of γ-methacryloxypropylmethyldimethoxysilane (manufactured by Nippon Unicar Co.) as a first photo-setting component was prepared. In addition, 1g of a mixed solution of an aqueous

0.01N nitric acid solution and ethanol in a molar ratio of 2:1 was prepared. After these components were mixed and sufficiently stirred, the mixture was reacted by allowing to standing at 70°C for 12 hours. Then, the reaction product was dried at 70°C, and water and alcohol were removed by evaporation.

To 4g of this dried reaction product, 0.03g of a first photo-setting initiator and 16g of a ceramic powder were added. As the first photo-setting initiator, bis(2,4,6-trimethylbenzoyl)-phenylphosphine oxide commercially available from Ciba Geigy Co. under the trade name of Irgacure 819 was used. This first photo-setting initiator has an absorption edge at a wavelength of about 450 nm. As the ceramic powder, an α-alumina commercially available from Showa Denko Co. under the trade name of Al-45-2 was used. This α-alumina has an average particle diameter of 2.1 μm.

Then, a mold having a concave portion corresponding to the shape of a rib was prepared. This mold was formed from a second photo-setting component in the presence of 1% by weight of a second photo-setting initiator. As the second photo setting component, an aliphatic urethane acrylate oligomer commercially available from Henschel Co. under the trade name of Photomer 6010 was used. As the second photo-setting initiator, 2-hydroxy-2-methyl-1-phenyl-propan-1-one commercially available from Ciba Geigy Co. under the trade name of Dalocure 1173 was used. This initiator has an absorption edge at a wavelength corresponding to 380 nm. Photopolymerization of the second photo-setting component was conducted by exposure to ultraviolet light of 200 to 450 nm from an ultraviolet light source (trade name: Unicure) manufactured by Ushio Denki Co.

The concave portion of the mold was filled with the above photosensitive paste. Then, a transparent back plate was placed on this mold, thereby making contact with photosensitive paste in the concave portion. Using a fluorescent lamp manufactured by Philips Co., photopolymerization of the first photo-setting component was conducted by exposure to light having a wavelength of 400 to 500 nm for 30 seconds. Exposure to light was conducted simultaneously from both sides of the transparent mold and transparent substrate. Then, a molded article together with the back plate was removed from the mold. In this case, removal of the molded article from the mold could be conducted without

causing breakage of the molded article or back plate. Then, the molded article and back plate were put in a calcinating oven at 500°C to obtain a rib.

Comparative Example 1

In this example, the same photosensitive paste and mold as those in Example 1 were used. However, photopolymerization of the first photo-setting component was conducted by using the above ultraviolet light source in place of a fluorescent lamp manufactured by Philips Co. As a result, the back plate could not be removed from the mold, together with back plate, because of strong adhesion between the mold and molded article. The molded article was forcibly removed from the mold, resulting in breakage of the molded article.

Comparative Example 2

In this example, the same photosensitive paste as that in Example 1 was used. However, the mold in this example was made by using the second photo-setting component and first photo-setting initiator of Example 1 in place of the second photo-setting component and second photo-setting initiator. In this case, photopolymerization of the second photo-setting component for obtaining the mold was conducted by using the above ultraviolet light source.

After the concave portion of the mold was filled with the above photosensitive paste, photopolymerization of the first photo-setting component for obtaining a rib precursor was conducted by using the above fluorescent lamp. As a result, the back plate could not be removed from the mold, together with back plate, because of strong adhesion between the mold and molded article. The molded article was forcibly removed from the mold, resulting in breakage of the molded article.

Effect of the Invention

According to the method of producing the substrate for PDP of the present invention, breakage of the base and rib is avoided and the mold can be repeatedly used.

CLAIMS

1. A method of producing a substrate for a plasma display panel by providing a rib on a base, which comprises the steps of
   - contacting a rib precursor containing a first photo-setting initiator having a first absorption edge and a first photo-setting component closely with said base,
   - filling a mold, obtained by photo-setting of a second photo-setting initiator having a second absorption edge whose wavelength is shorter than a wavelength corresponding to said first absorption edge of said first photo-setting initiator, with said rib precursor,
   - exposing said rib precursor to light having a wavelength longer than a wavelength corresponding to said second absorption edge, thereby setting said rib precursor, and
   - removing said mold.

2. A method of producing a substrate for a plasma display panel by providing a rib on a base, which comprises the steps of
   - filling a mold, obtained by photo-setting of a second photo-setting initiator having a second absorption edge whose wavelength is shorter than a wavelength corresponding to said first absorption edge of said first photo-setting initiator, with a rib precursor containing a first photo-setting initiator having a first absorption edge and a first photo-setting component,
   - contacting said rib precursor closely with said base,
   - exposing said rib precursor to light having a wavelength longer than a wavelength corresponding to said second absorption edge, thereby setting said rib precursor, and
   - removing said mold.

3. The method according to claim 1 or 2, wherein the base and mold are transparent and exposure of the rib precursor to light is conducted via the base and mold.

4. The method according any one of claims 1 to 3, wherein the mold is flexible.

5. The method according to any one of claims 1 to 4, wherein the first photo-setting initiator has the first absorption edge corresponding to a wavelength of 400 to 500 nm and the second photo-setting initiator has the second absorption edge corresponding to a wavelength of 300 to 400 nm.

6. The method according to any one of claims 1 to 5, wherein the first photo-setting component and second photo-setting component are acrylic resin.

7. The method according to any one of claims 1 to 6, wherein the rib precursor contains a powder of ceramic and optionally contains a powder of glass.

8. An assembly of a mold for making a substrate for a plasma display device panel comprising a base and ribs, said mold having concave portions, and a rib precursor for forming said ribs said rib precursor being disposed in said concave portions of said mold and containing a first photo-setting initiator having a first absorption edge and a first photo-setting component, said mold being obtained by photo-setting a second photo-setting component in the presence of a second photo-setting initiator having an absorption edge whose wavelength is shorter than a wavelength corresponding to said first absorption edge of said first photo-setting initiator.

9. The assembly according to claim 8, wherein said mold is flexible.

10. The assembly according to claim 8 or 9, wherein said mold is transparent.

11. The assembly according to any one of claims 7 to 9, further comprising a glass substrate forming the base of the substrate for the plasma display panel, said glass substrate contacting said rib precursor disposed in the concave portions of said mold.

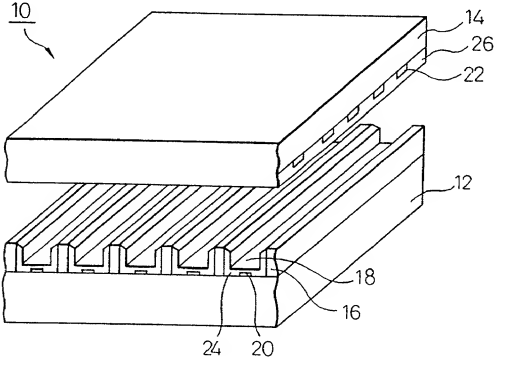

Fig. 1

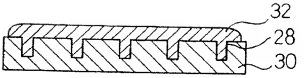

Fig. 2A

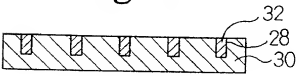

Fig. 2B

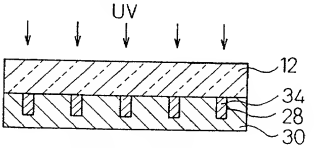

Fig. 2C

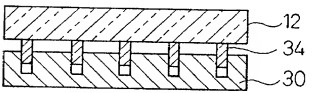

Fig. 2D

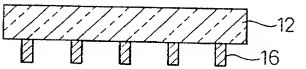

Fig. 2E

DECLARATION, POWER OF ATTORNEY, AND PETITION

I, a below named inventor, depose and say that: (1) my residence, citizenship, and mailing address are indicated below; (2) I have reviewed and understand the contents of my patent application, including the claims, as amended by any amendment specifically referred to herein, which is identified as PCT International Patent Application Serial No. PCT/US00/03953 filed 16 February 2000, bearing Attorney Docket Number 54769PCT1A.003; (3) I believe that I am the original, first, and sole inventor or discoverer of the invention or discovery in

METHOD OF PRODUCING SUBSTRATE FOR PLASMA DISPLAY PANEL

AND MOLD USED IN THE METHOD

described and claimed therein and for which a patent is sought; and (4) I hereby acknowledge my duty to disclose to the Patent and Trademark Office all information known to me to be material to the patentability as defined in Title 37, Code of Federal Regulations, §1.56*, and that no application for patent or inventor's certificate on this invention or discovery has been filed by me or my legal representatives or assigns in any country foreign to the United States of America except Japan Application No. 11-82003 filed 25 March 1999 upon which I hereby claim foreign priority benefits under Title 35, United States Code Section 119.

I hereby appoint Gregory D. Allen (Reg. No. 35,048), Alan Ball (Reg. No. 42,286), Scott A. Bardell (Reg. No. 39,594), Carolyn A. Bates (Reg. No. 27,853), Bruce Black (Reg. No. 41,622), Colene E. H. Blank (Reg. No. 41,056), Jennie G. Boeder (Reg. No. 28,952), William J. Bond (Reg. No. 32,400), Arthur J. Brady (Reg. No. 42,356), Stephen W. Buckingham (Reg. No. 30,035), John A. Burtis (Reg. No. 39,924), Melissa E. Buss (Reg. No. 47,465), Gerald F. Chernivec (Reg. No. 26,537), James D. Christoff (Reg. No. 31,492), Philip Y. Dahl (Reg. No. 36,115), Janice L. Dowdall (Reg. No. 31,201), Lisa M. Fagan (Reg. No. 40,601), Carolyn A. Fischer (Reg. No. 39,091), Yen T. Florczak (Reg. No. 45,163), Darla P. Fonseca (Reg. No. 31,783), Melanie G. Gover (Reg. No. 41,793), Christopher D. Gram, (Reg. No. 43,643), Gary L. Griswold (Reg. No. 25,396), Doreen S. L. Gwin (Reg. No. 35,580), Michaele A. Hakamaki (Reg. No. 40,011), Karl G. Hanson (Reg. No. 32,900), Dean M. Harts (Reg. No. 47,634), Néstor F. Ho (Reg. No. 39,460), Rudolph P. Hofmann, Jr. (Reg. No. 38,187), Robert W. Hoke (Reg. No. 29,226), MarySusan Howard (Reg. No. 38,729), Stephen C. Jensen (Reg. No. 35,207), Robert H. Jordan (Reg. No. 31,973), Harold C. Knecht III (Reg. No. 35,576), Kent S. Kokko (Reg. No. 33,931), Douglas B. Little (Reg. No. 28,439), Eloise J. Maki (Reg. No. 33,418), Matthew B. McNutt (Reg. No. 39,766), Michelle M. Michel (Reg. No. 33,968), William D. Miller (Reg. No. 37,988), Peter L. Olson (Reg. No. 35,308), Daniel R. Pastirik (Reg. No. 33,025), David B. Patchett (Reg. No. 39,326), Robert J. Pechman (Reg. No. 45,002), Carolyn V. Peters (Reg. No. 33,271), Scott R. Pribnow (Reg. No. 43,869), Ted K. Ringsred (Reg. No. 35,658), Steven E. Skolnick (Reg. No. 33,789), Robert W. Sprague (Reg. No. 30,497), Brian E. Szymanski (Reg. No. 39,523), James J. Trussell (Reg. No. 37,251), Lucy C. Weiss (Reg. No. 32,834), Bradford B. Wright (Reg. No. 34,459), and Kimberly S. Zillig (Reg. No. 46,346) my attorneys and/or agents with full powers (including the powers of appointment, substitution, and revocation) to prosecute this application and any division, continuation, continuation-in-part, reexamination, or reissue thereof, and to transact all business in the Patent and Trademark Office connected therewith; the mailing address and the telephone number of the above-mentioned attorneys and/or agents are

Attention: Robert J. Pechman
Office of Intellectual Property Counsel
3M Innovative Properties Company
P.O. Box 33427
St. Paul, Minnesota 55133-3427
Telephone No. 651/737-0631

The undersigned petitioner declares further that all statements made herein of his own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

*Title 37, Code of Federal Regulations, §1.56 is attached.

§1.56 Duty to disclose information material to patentability.

(a) A patent by its very nature is affected with a public interest. The public interest is best served, and the most effective patent examination occurs when, at the time an application is being examined, the Office is aware of and evaluates the teachings of all information material to patentability. Each individual associated with the filing and prosecution of a patent application has a duty of candor and good faith in dealing with the Office, which includes a duty to disclose to the Office all information known to that individual to be material to patentability as defined in this section. The duty to disclose information exists with respect to each pending claim until the claim is cancelled or withdrawn from consideration, or the application becomes abandoned. Information material to the patentability of a claim that is cancelled or withdrawn from consideration need not be submitted if the information is not material to the patentability of any claim remaining under consideration in the application. There is no duty to submit information which is not material to the patentability of any existing claim. The duty to disclose all information known to be material to patentability is deemed to be satisfied if all information known to be material to patentability of any claim issued in a patent was cited by the Office or submitted to the Office in the manner prescribed by §§ 1.97(b)-(d) and 1.98. However, no patent will be granted on an application in connection with which fraud on the Office was practiced or attempted or the duty of disclosure was violated through bad faith or intentional misconduct. The Office encourages applicants to carefully examine:

(1) prior art cited in search reports of a foreign patent office in a counterpart application, and

(2) the closest information over which individuals associated with the filing or prosecution of a patent application believe any pending claim patentably defines, to make sure that any material information contained therein is disclosed to the Office.

(b) Under this section, information is material to patentability when it is not cumulative to information already of record or being made of record in the application, and

(1) It establishes, by itself or in combination with other information, a prima facie case of unpatentability of a claim; or

(2) It refutes, or is inconsistent with, a position the applicant takes in:

(i) Opposing an argument of unpatentability relied on by the Office, or

(ii) Asserting an argument of patentability.

A prima facie case of unpatentability is established when the information compels a conclusion that a claim is unpatentable under the preponderance of evidence, burden-of-proof standard, giving each term in the claim its broadest reasonable construction consistent with the specification, and before any consideration is given to evidence which may be submitted in an attempt to establish a contrary conclusion of patentability.

(c) Individuals associated with the filing or prosecution of a patent application within the meaning of this section are:

(1) Each inventor named in the application;

(2) Each attorney or agent who prepares or prosecutes the application; and

(3) Every other person who is substantively involved in the preparation or prosecution of the application and who is associated with the inventor, with the assignee or with anyone to whom there is an obligation to assign the application.

(d) Individuals other than the attorney, agent or inventor may comply with this section by disclosing information to the attorney, agent, or inventor.

Wherefore, I pray for grant of Letters Patent for the invention or discovery described and claimed in the aforementioned specification and I hereby subscribe my name to the foregoing specification and claims, declaration, power of attorney, and this petition, on the day set forth below.

Aug 8, 2001

Chikafumi Yokoyama — Date

Residence: 5-12-41-102, Surge, Tamaku, Kawasaki-shi, Kanagawa 214-0001, JAPAN

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